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ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Regeneration On An Aspen Clearcut in Arizona

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Approximately 14,000 root suckers per acre sprouted on a 5-acre clearcut. After four growing seasons, about 10,700 per acre were still alive, and mil-acre stocking was 98 percent. The tallest sucker on the average mil-acre plot was 10.5 feet; the tallest on any plot was 17.4 feet. Stocking density was irregular. Thinly stocked spots seemed largely associated with slash concentrations, haul roads, and main skid trails. Browsing by elk was widespread but not generally severe. The suppressive effect of bordering timber was restricted to a trivial strip along the south border.

Keywords: *Populus tremuloides*, clearcutting, root suckers, growth, stand structure, apical dominance.

Foresters, ecologists, and wildlife managers are concerned that the acreage of aspen[2] forest in the western United States may decrease drastically over the decades to come (Beetle 1974, Hinds and Krebill 1975, Jones 1974, Krebill 1972, Patton and Jones 1975). The great preponderance of aspen stands in the West are mature or overmature. Although heavy partial cutting may maintain the type, a satisfactory new stand seems to require something approaching complete removal of the overstory (Baker 1918, 1925; Sampson 1919; Zehngraff 1949). The old source of regeneration, wildfire, seldom burns aspen stands today. In the absence of a well-stocked coniferous understory, aspen forest does not burn readily, and light fire does not kill the overstory (Horton and Hopkins 1965). The holocausts that burned large areas, including aspen stands, in the past are considered too destructive and dangerous to allow.

Clearcutting has successfully regenerated millions of acres of aspen in the Lake States. Its effectiveness has also been demonstrated on a small scale in Utah (Baker 1925, Sampson 1919, Smith et al. 1972).

Aspen clearcutting has been limited in the West, however, by poor markets, especially for small-diameter trees. Thus, even where there has been appreciable logging of aspen, most of it has been market selection, amounting roughly to a diameter-limit cutting. While considerable regeneration often results, it tends to be patchy, with much of it suppressed by the overstory. These irregular stands are then subject to damage and consequent disease as the residual overstory becomes decadent and blows down.

Improving markets are making aspen clearcutting more feasible. At the same time, however, increasing public unhappiness over the esthetic impacts of many

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[2]*Common and scientific names of plants mentioned are listed on page 8.*

past clearcuttings have made managers understandably cautious about further clearcutting.

In May and June 1970, the Alpine Ranger District, Apache National Forest, cut an irregular 5-acre (2-ha) clearing in a well-stocked stand of large aspen. The purpose was to demonstrate that a small clearcutting could be made on a slope facing a highway without adverse esthetic impact. The demonstration was successful. The irregular terrain has a mosaic of naturally different stand conditions, and the trees bordering the downslope edge of the clearing screen the ground from view. The clearcut must be carefully pointed out to be seen from the road.

The area also provided an opportunity to evaluate regeneration following a clearcutting in a southwestern aspen stand.

The Area

The study area, on the headwaters of the San Francisco River, is at 8,400 feet (2,560 m) elevation on a north-facing slope. Associated coniferous stands are a mixture of ponderosa pine, Douglas-fir, white fir, southwestern white pine, and aspen. Gambel oak occurs as scattered individuals and patches.

The weather station at Alpine, Arizona is 2 miles (3.2 km) east in the same valley, and 400 feet (120 m) lower. Precipitation there averages 19.21 inches (487 mm) yearly, 6.97 inches (177 mm) falling as monsoon rains in July and August, and 6.40 inches (162 mm) as snow from November through March. Based on limited records, temperatures average about 63°F (17°C) in July and 28°F (-2°C) in January.

The soils, derived from basic volcanics, are deep and fine textured. In the healthy 70-year-old parent stand, dominants measured from 77 to 96 feet (23 to 29 m) tall at different points around the perimeter of the clearcutting, indicating an excellent aspen site by western standards.

Objectives

The study had three objectives: (1) to describe stocking and height growth four summers after logging; (2) to describe the development of structure and natural thinning in young western stands; and (3) to examine the effects of stand edge on suckering and sucker growth.

Methods

Data were collected late in May 1974. Sampling was of two kinds: (1) Live and dead suckers were counted on mil-acre (4 m^2) quadrats, and height was determined for 1970, 1971, 1972, and 1973 for the tallest sucker on each quadrat. Bud scars were used to determine how tall the trees had been at the end of each summer. These 81 plots were located uniformly along systematically spaced lines, and are referred to as **line plots.** (2) Tree class (free or overtopped) and yearly height of all live suckers were recorded on six 1-mil-acre quadrats, and dead suckers were counted. These six plots, referred to as **census plots,** were selectively located.

The **line plots** were established along nine transects. Each transect extended from within the old growth out into the clearcut. Four transects extended into the clearcut from the south, where the edge of the clearcut was shaded throughout the day by the mature stand. Five others extended from the west-northwest, where the edge of the clearcut was exposed to the sun throughout the morning and during midday. Other orientations were not used because of scattered old aspen left in parts of the clearing.

Plots were spaced 20 feet apart on the lines. On each line, the fourth plot was barely within the clearcut, on a line between two edge trees. Plots 1-3 were at intervals back into the stand. Plots 5-9 were at increasing distances out into the clearcut.

The **census plots** were located in the clearcut away from the edge, and avoided the small, lightly stocked "gaps" scattered throughout the sucker stand. They were intended to represent conditions of heavy competition.

Results

Edge Effects

Suckers were few and small along the continually shaded south edge of the clearcut. This shaded-edge effect was conspicuous and ended rather abruptly 15-20 feet (4-6 m) into the clearcut (fig. 1). Only two of the four shaded-edge plots were stocked. Their tallest suckers averaged 4.2 feet (128 cm). Away from the shaded edge, 98 percent were stocked, and their tallest trees average 10.5 feet (3.2 m).

Along the sunny edge of the clearcut, in contrast, neither restocking nor growth was depressed (fig. 2). In fact, where the sun shone into the edge of the mature stand throughout the morning, suckers were numerous beneath the canopy, although small and declining.

The area of affected strip along the shaded edge is trivial, and by the time the new stand is mature it should be canopied by adjacent trees. Because its representation in our sample is disproportionately large, data from the shaded edge will not be included in describing the clearcut.

Figure 1.— Poorly stocked strip along shaded edge, with normal regeneration on left.

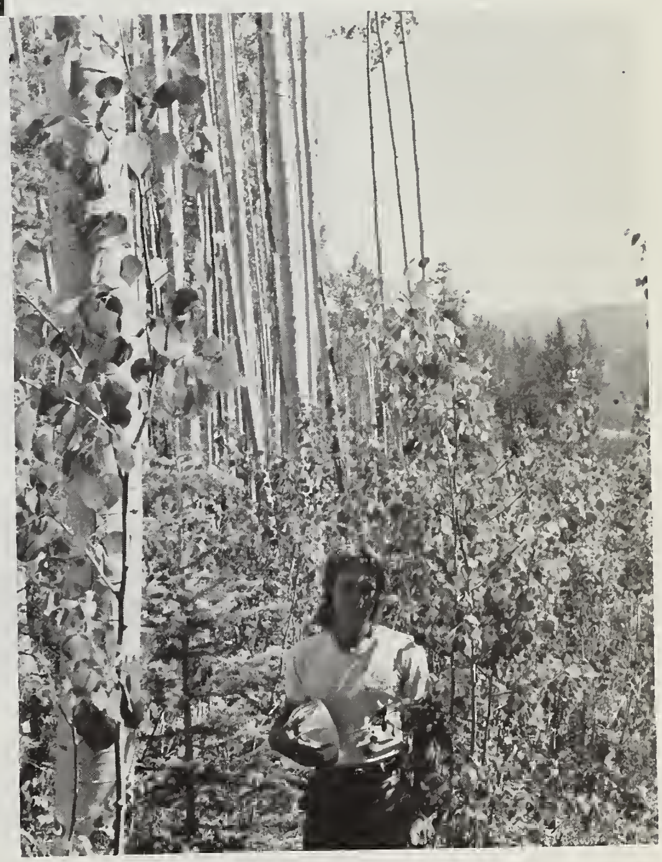

Figure 2.— Sunny edge of clearcut, with normal regeneration.

Stocking

Mil-acre stocking within the clearcut approached 100 percent. Only one of the 50 plots had no live sucker, even though some plots fell within the small "gaps" in the regeneration stand.

The number of suckers tallied, alive and dead, averaged 13,760 $\pm$ 1,305 per acre (34,000 $\pm$ 3,223 per ha), with 10,660 $\pm$ 973 per acre (26,300 $\pm$ 2,404 per ha) surviving. Some additional suckers may have sprouted, died, and disappeared. These were probably few, however, as numerous very small dead suckers were readily identified, even though some appeared to have been dead for two summers or more and lay on the ground. Therefore, total suckering since logging probably did not exceed about 14,000 per acre (34,600 per ha).

Some of the small gaps within the sucker stand were associated with slash concentrations (fig. 3), some with truck trails or main skid trails, and some with mounds of decayed wood marking old slumped coniferous windfalls. Still others had no apparent cause. Most gaps are too small to affect mature stocking.

The Dominant Stand

Many of the 10,660 live suckers per acre are overtopped, broken, or seem otherwise likely to die young. The mature canopy will be made up entirely or almost entirely of suckers now in a favorable competitive position—those that are presently tallest and most vigorous. On the average line plot, the tallest tree was 10.5 $\pm$ 0.5 feet (3.21 $\pm$ 0.14 m) at the end of 1973, with a standard deviation of 3.2 feet (98 cm).

Suckering began in 1970, but most took place later. When the tallest tree on each plot is con-

Figure 3.—Looking across lightly stocked gap where slash lay concentrated. Stocking behind the man is heavier than normal for this clearcut.

sidered, 19 originated in 1970 and 30 in 1971. Most of those starting in 1970 grew less their first season than those which started in 1971: 1.8 feet (54 cm) compared to 3.2 feet (96 cm). Those of 1970 origin average taller, however, because of their earlier start.

The greatest first-year height for any measured sucker was 4.9 feet (149 cm). At the end of 1973 the tallest line-plot tree, four summers old, stood 17.4 feet (5.3 m).

Stand Structure

The six census plots provided a limited picture of developing stand structure where competition is severe. They were located to avoid the lightly stocked gaps, and three were located to sample exceptionally heavy stocking. Stocking with live suckers in May 1974 ranged from 9,000 to 24,000 per acre (22,200 - 59,300 per ha). Most (96 percent) of the live trees had sprouted in 1970 or 1971. One percent pre-dated logging. Three percent did not sprout until 1972, when competition was already severe; they were overtopped when examined.

Growth and structural differentiation is indicated by the numbers of live suckers in different height classes on each census plot (table 1). The large range in heights, combined with the density of stocking, reflects differentiation into crown classes. By May of 1974, 38 percent of all suckers on the census plots had died. In addition, nearly half the live aspen, 42 percent, were overtopped by branches of larger aspen. They can be expected to decline and die during the next decade or so. The mortality and structural differentiation in this stand is consistent with that described by Pollard (1971) for young aspen in eastern Ontario, Canada.

Table 1.--Size class distribution of live suckers on census plots at the end of 1973

English System			Metric System		
Height class	Average per acre ± standard error	Percent	Height class	Average per hectare ± standard error	Percent
ft	*no.*		*m*	*no.*	
0 - 2.0	500 ± 57	3	0 -0.61	1,235 ± 141	3
2.1- 4.0	667 ± 45	4	0.62-1.22	1,648 ± 111	4
4.1- 6.0	2,167 ± 208	14	1.23-1.83	5,355 ± 514	14
6.1- 8.0	3,500 ± 112	22	1.84-2.44	8,649 ± 277	22
8.1-10.0	3,000 ± 105	19	2.45-3.05	7,413 ± 259	19
10.1-12.0	1,667 ± 93	11	3.06-3.66	4,119 ± 230	11
12.1-14.0	2,833 ± 194	18	3.67-4.27	7,000 ± 479	18
14.1 +	1,333 ± 111	9	4.28 +	3,294 ± 274	9
Total	15,667 ± 398	100		38,713 ± 983	100

Damage and Mortality

No effort was made to account for causes of all mortality or severe damage, but many observations were recorded. Numerous dead trees had been girdled by rodents. Many live trees had been partly girdled; many of these had partly callused over and seemed in good health.

Browsing had been widespread and was often associated with breakage. Fairly large shoots had been broken and browsed. Many of these were alive but deformed and overtopped. Elk are known to pull or ride down aspen saplings to browse upon (Beetle 1974). Judging from droppings and the height of some of the browsing, elk, rather than deer or cattle, were largely responsible. Within the uncut stand, most suckers had been browsed. On a well-defined area of about ¼ acre in a corner of the clearcut, mortality from browsing had been substantial and almost all survivors were severely browsed (fig. 4). Other than in this small area, browsing within the clearcut, though appreciable, has not harmed the new stand importantly.

The heavily browsed corner was not sampled.

Discussion

Spring clearcutting in this healthy 70-year-old aspen stand resulted in quick, abundant regeneration by suckering. The resultant large number of suckers per acre, about 13,760 (34,000 per ha), were nonetheless far fewer than on some exceptional Utah clearcuts tabulated below:

Source	**No. of Suckers**	
	Per acre	*Per ha*
Baker (1925, p. 22)	110,000	271,800
Sampson (1919)	85,500	211,300
Smith et al. (1972)	59,000	145,800

Barnes (1969) and Tew (1970) found marked differences in sucker production of different quaking aspen clones. This difference seems related, at least in part, to clonal differences in levels of carbohydrate reserves (Tew 1970, Schier and Johnston 1971). In the West, where single clones frequently cover several acres, such clonal differences may account for sizable differences in the density of suckering. However, environmental differences probably also can be major factors.

Figure 4.—Severely browsed regeneration, with normal regeneration behind it.

Baker (1925) also found that few additional suckers sprout on aspen clearcuts after the second year. Certainly, in the present study, suckering during the first two growing seasons after cutting seems more than adequate. Furthermore, suckers present by the end of the second summer will apparently constitute the entire mature canopy.

Most published data on sucker growth rates in the West are from Utah, and are averages of all size classes. Sampson (1919) reported that, four growing seasons after spring clearcutting, the average sucker was 3.41 feet (1.04 m) tall. Baker (1925) gave an average height of 4.23 feet (1.29 m) after four growing seasons. Smith et al. (1972) reported 3,529 suckers per acre (8,720 per ha) taller than 5 feet (1.52 m) at the end of four growing seasons, 13 percent of the total stocking on that area. In a northern Arizona study,[3] average heights on a clearcut were 4.9 feet (1.51 m) after four growing seasons, increasing to 10.1 feet (3.08 m) by the end of the seventh. Clearly, early growth on the clearcut in the present study has been better than that reported elsewhere for the West. Stem analyses of much older aspen stands on the Apache National Forest suggest that it is also better than usual for this area. Therefore the growth found here indicates what will sometimes be attained, not what can be expected.

An edge effect had been anticipated. Shade inhibits both suckering and growth, (1) since the ground heating that results when the shading canopy is removed stimulates suckering (Sandberg and Schneider 1953, Maini and Horton 1966) and (2) because aspen is very intolerant of shade. In addition, physiological research has shown that established aspens can impede suckering on connected roots and reduce the growth of new suckers. Two factors seem to contribute to this "apical dominance" effect: a growth regulator produced in the shoot apex and translocated to the roots, and the tendency of stored energy reserves to move toward established energy sinks (Farmer 1962, Maini 1966, Schier 1972).

In a Manitoba sapling stand, Steneker (1974) found that exposure of the ground to full sunlight without breaking apical dominance produced very few suckers, although the ground surface was warmed to temperatures found in clearcuttings. In contrast, breaking apical dominance while leaving the ground shaded produced many suckers. Steneker's work suggests that suckering after logging or fire may be due largely to removal of the apical dominance mechanism rather than to soil warming.

In this study, if roots of uncut border trees had not suckered, or had produced weak suckers, regeneration along the sunlit edge would have been strongly reduced in numbers or vigor; however, neither was reduced. Furthermore, 3-year-old suckers were rather numerous, though weak and declining, within the uncut stand where the adjacent cutting provided increased sunlight. In contrast, suckering and sucker growth were markedly less where the bordering stand continually shaded the clearcut.

Aspen regeneration and sheep are not compatible until the aspen are about 4 feet (1.2 m) tall (Baker 1925, Sampson 1919, Smith et al. 1972). Browsing by deer and elk has also been considered a threat to successful aspen regeneration on burns and clearcuts, especially where the disturbed acreage is small. Jones (1967) reported the elimination of initially numerous aspen suckers by big-game on 98 acres (40 ha) of mixed conifer clearcuts on the Apache National Forest between 1960 and 1964. Smith et al. (1972) indicate that this happens only with exceptional browsing pressures, and populations of both elk and mule deer were very high on the Apache in the early 1960's. Because of its small size, the clearcut in this study had the potential to concentrate browsing quite strongly. Browsing did not seriously affect regeneration, however. The present big-game population in the general area is believed to be moderately below carrying capacity.[4] Also, damage might have been more significant were it not for the speed with which the tops of this particular sucker stand grew out of convenient reach.

Conclusions

Considered in conjunction with findings in other regions, and the known ecology of aspen, this study suggests that clearcutting in southwestern aspen stands is very likely to result in quick and complete regeneration by aspen suckers. On favorable sites, early growth can be very rapid. Inhibition of suckering and sucker growth by the adjacent uncut stand seems likely to be trivial.

Deer and elk are attracted to clearcuts. Where numbers of big-game and cattle are moderate and early growth is exceptional, clearcuts as small as 5 acres (2 ha) may not be seriously damaged. Generally, however, aspen clearcuts should be somewhat larger than 5 acres, or, if small, there should be enough of them in the general area to spread browsing use by big-game.

[3] *M. M. Larson. 1958. Aspen regeneration methods in the Southwest. (Office report in the files of the Rocky Mt. For. and Range Exp. Stn., Flagstaff, Ariz.)*

[4] *Personal communication from John K. Adams, Wildlife Biologist, Apache National Forest.*

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Common and Scientific Names of Plants Mentioned

Aspen (quaking)	*Populus tremuloides* Michx.
Douglas-fir (Rocky Mountain)	*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco
Gambel oak	*Quercus gambelii* Nutt.
Ponderosa pine	*Pinus ponderosa* Laws.
Southwestern white pine	*Pinus strobiformis* Engelm.
White fir	*Abies concolor* (Gord. & Glend.) Lindl.

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